MOBIL MUNKAGÉPEK MODULÁRIS TERVEZÉSÉNEK GAZDASÁGOSSÁGI ASPEKTUSA

ASPECT OF FINANCIAL EFFICIENCY OF MODULAR DESIGN OF MOBILE WORKING MACHINES

Ladislav GULAN, Juraj BUKOVECZKY

ABSTRACT

Relation between costs invested on design activities and their revaluating into produced machines, particularly in case of modular design technique, is important information for a company producing mobile working machines. This information is important especially by innovation already existing production program, also by decisions, which products, eventually their modifications include into production program in the future. For the purpose of such decisions, it is suitable to use evaluation of structures modularity via the so called coefficient of financial efficiency, which can support decisions about creation a new, eventually expension of existing production program.

Keywords: *modular structure, mobile working machine, coefficient of financial efficiency, modularity ratio*

1. INTRODUCTION

The market of mobile working machines is filled in with a broad offer of various types and size classes of machines. Every producer must hence constantly follow and evaluate requirements of users, so as to be able objectively to determine production program for the future. On the basis of knowledge of contemporary situation are then designers able to create suitable structure of basic building modules, from which will then be possible to assemble required structural variants of mobile machines determined for realization of particular working technologies. Efficiency of in this way created structures can be assessed via modularity ratio. Modularity ratio expresses degree of use of building modules and regards various facts and relations among assembled machines, their structures, number of disponible variants of particular modules as well as problems of creation of a mutual platform [1], [2].

Prerequisite of a successful acting of a company producing mobile working machines on market, and its competitiveness, is also an offer of a sufficient assortment of machines enabling realization of more than one working technologies. This offer is usually objectified by requirements of users. These requirements have to be in the initial phase of design evaluated and required assortment has to be reduced by restriction of number of universal working machines, for which flexible modular structures on a mutual platform have to be created and their modularity ratio as the criterion for design of definitive variants of working machines will be assessed fig. 1. After considering contemporary requirements of users, the set of basic machines of a building sequence was widened with further variants and virtually a modular structure of a carrier HON 200 from existing building modules was created.

2. MODULAR DESIGN OF MOBILE WORKING MACHINES

Costs for development of a new mobile working machine usually exceeds the limit 0,5 million €, a new product must then inevitably be economically successful. Problems of creation of a suitable products structure on a mutual platform is solved in the stages of the project APVV-0100-06 „Research of a Modular Platform for an Oriented Segment of Mobile Working Machines“. This project created the basis for the development and design of new mobile working machines with type marking HON 200. In case of basic machines with type marking HON 200Z and HON 200T (fig.1 – blue background) the pre-production phase was finished including production and testing of prototype, process of approval of a new product and piece production was launched. Presented methodology of structures assessment should contribute to design process of a pilot production program, eventually to its subsequent expansion with further loadability class

Created was then a machine group, which aside basic types HON 200Z and HON 200T is composed of articulated loader with Z-kinematics HON200 KZ, articulated loader with a telescopic equipment HON 200KT, manipulator HON 200M, high lift manipulator HON 200H, articulated vibratory roller HON 200V, articulated compactor HON 200C and backhoe loader HON 200RN, fig. 1.

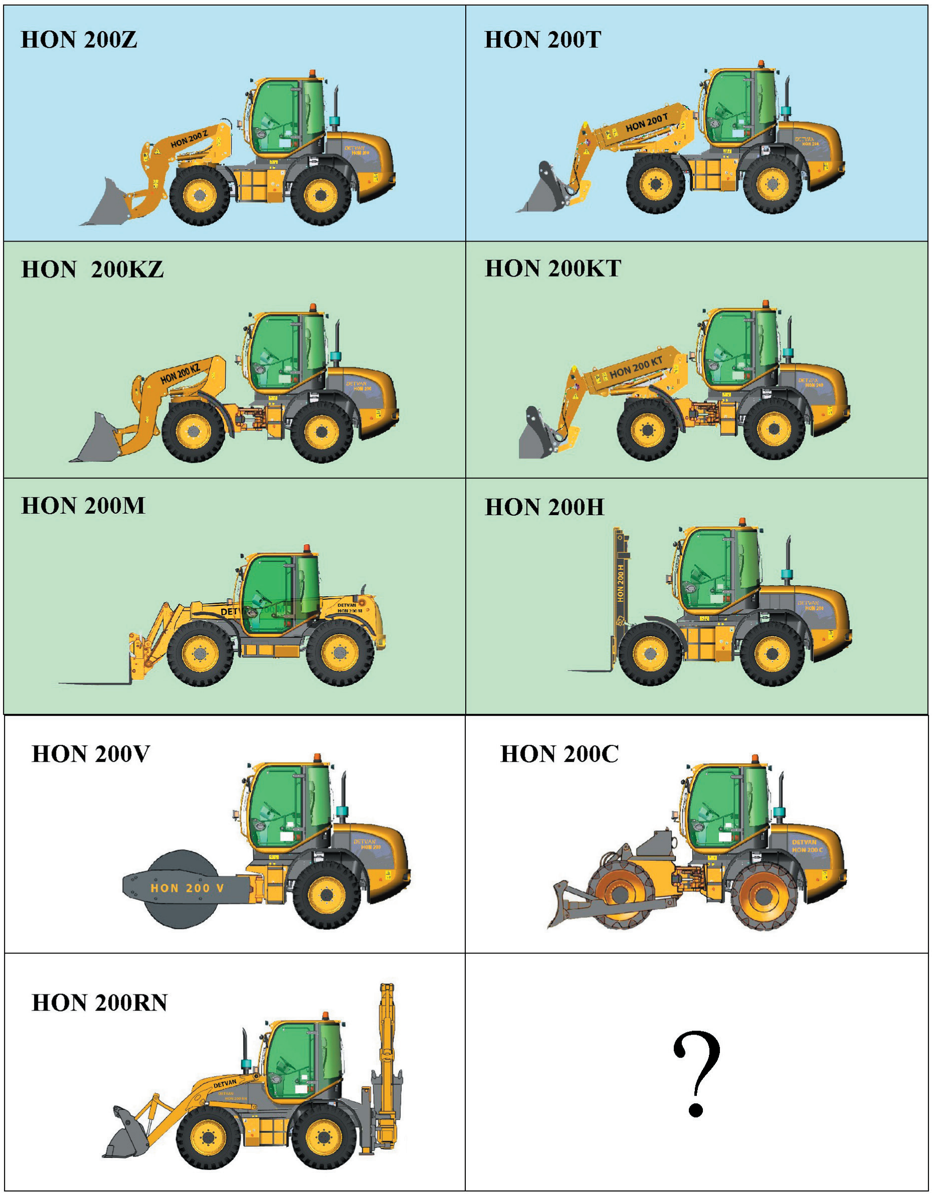

Fig. 1: Modular structure of a carrier HON 200

3. RATING OF FINANCIAL EFFICIENCY OF PLANNED PRODUCTION PROGRAM

For a production company is very important not only the information about degree of use of particular building modules, but also about relation between costs, which have to be spent on design activities and revaluating of these costs into products produced in frame of a particular production program [4]. Such information is important not only for an already existing production program, but also for decisions, which further products, eventually modifications of already existing should be included into a production program.

For this purpose we define the so called coefficient of financial efficiency – k_{FE}, which can provide relevant support in decisions about creation, eventually widening of production program. Proposed methodology of evaluation can be realized with the use of chart. 1. In this table we consider a production program of λ machines S_1 to S_λ. Particular machines are assembled from modules M_1 to $M\rho$.

Every module, which participates in creation of these machines, can occur in one or several variants.

In this chart the following symbols are used:

ρ – is the number of modules in consideration

$r = 1, ..., \rho$ – is the sum index with respect to all modules for the computation of values S_V and S_{ZM}

S_V – is the sum of financial costs for procuration of all needed variants of all modules

S_{ZM} – is the sum of evaluation of all variants of modules into all machine assemblies.

$F_{Mr}.V_o$ - are financial costs needed for procuration of o-th variant of r-th module

ω_r - is number of variants of r-th module

o = 1, ..., ω_r is the sum index for summing of financial costs needed for procuration of all variants of r-th module.

$\sum_{o=1}^{\omega_r} F_{Mr}.V_o$ - are financial costs needed for procuration of all variants of r-th module.

$S_V = \sum_{r=1}^{\rho}\sum_{o=1}^{\omega_r} F_{Mr} V_o$ are financial costs needed for procuration of all variants of all modules.

λ – is the number of machines of a production program L = 1 ,.., λ – is the sum index regarding all the machines for computation of values S_V and S_{ZM}

$F_{Mr}\ V_{SL}$ is financial value of the r-th module in that particular variant, which is used for the creation of the L-th machine , for r = 1 ,..., ρ, L = 1 ,.., λ

$\sum_{r=1}^{\rho} F_{Mr} V_{SL}$ - is the financial evaluation of all used modules for the L-th machine, while mentioned evaluation is implied by creation of particular machine.

$S_{ZM} = \sum_{L=1}^{\lambda}\sum_{r=1}^{\rho} F_{Mr} V_{SL}$ - is the evaluation of all used variants of all modules implied by creation of all machines of particular production program.

Note: In computation of the

$S_{ZM} = \sum_{L=1}^{\lambda}\sum_{r=1}^{\rho} F_{Mr} V_{SL}$ - are the values of particular variants in the sum applied in every machine while in computation of

$S_{ZM} = \sum_{L=1}^{\lambda}\sum_{r=1}^{\rho} F_{Mr} V_{SL}$ - are the values of particular variants applied only in the first use, when they have to be designed.

The main base of efficiency of creation of modular structures is put well by the ratio of S_V and S_{ZM}, the values of which change depending on number of variants of particular modules, produced in the assortment of machines of particular production program.

Let us denote this ratio as

$$k = \frac{S_V}{S_{ZM}} \qquad (1)$$

The coefficient k is positive and from the very base of definition of values S_V a S_{ZM} it implies that $k \in (0,1)$. Then the coefficient of financial efficiency of production program k_{FE} can be defined as follows

$$k_{FE} = 1 - k \qquad (2)$$

where it holds good that $k_{FE} \in (0,1)$ and the higher the usability of particular modules, the higher is the value k_{FE}. This methodology can provide a producer with a support in decisions, about expanding or change of production program of a company.

For two, possibly more alternatives of production program, changes of particular indices k_{FE} will be evaluated and to the extent, that decisions will not be influenced by some other factors, the alternative with the highest value of index k_{FE} can be recommended.

On the basis of comparison of modularity ratio and coefficient of financial efficiency for the group of machines, it is necessary in preproduction stage, responsible to decide, which types of variant structures will actually be realized in design stages and prepared for the final production. Such decisions will be influenced by many factors, from which the most important are the needs of real market and affinity of working technologies, which will be performed by considered machines. On the basis of these criteria, the extent of modular solutions can be specified. For a factual case after a detailed research of market requirements and considering concrete possibilities and requirements of producer it would be purposeful to select for the pilot program the group of variant structures depicted in the (fig. 1 – blue and green background).

For this group of machines, assurance of one working technology is characteristic – manipulation with material – using two types of working tools, loading shovel and manipulation forks. Just working technologies realized by these tools belong to the most widespread and users require very often their mutual exchangeability. But specific are carriers with their building modules, enabling various ways of machine control, their maneuverability and manipulation suitable for various areas of their use in praxis.

Chart 1: Map of modular problem

Machine / Modul	S_1		S_L			S_λ	
M_1	$F_{M1}V_1$			$F_{M1}V_{\omega 1}$			$\sum_{o=1}^{\omega_1} F_{M1}V_o$
M_r							$\sum_{o=1}^{\omega_r} F_{Mr}V_o$
M_ρ							$\sum_{o=1}^{\omega_\rho} F_{M\rho}V_o$
	$\sum_{r=1}^{\rho} F_{Mr}V_{S1}$		$\sum_{r=1}^{\rho} F_{Mr}V_{SL}$			$\sum_{r=1}^{\rho} F_{Mr}V_{S\lambda}$	$S_V = \sum_{r=1}^{\rho}\sum_{o=1}^{\omega_r} F_{Mr}V_o$
	$S_{ZM} = \sum_{L=1}^{\lambda}\sum_{r=1}^{\rho} F_{Mr}V_{SL}$						

3. CONCLUSION

In the conclusion, it can be stated, that just modular structures enable flexible to create relevant production program of a company [2], [3]. These positive properties can briefly be summarized into the following points:

-flexibility for change of working technology

-flexibility for respecting of requirements of users

-positive influencing of logistic production chain

-shortening of design and technological production preparation

-shortening of innovation process and time needed for launching a product onto market

-decreasing of production costs

-simplification of production process

-diversity of products

-high number of variants.

Responsible producers of mobile working machines have to apply scientifically based methods of production program creation support, which is also proved by experience. Presented methodology of rating of modular structures is the contribution to creation of economically successful and sophisticated technological solutions of products. It is gratifying, that scientific cooperation in development of these progressive methods is supported by agencies in the form of mutual scientific-research projects with production companies.

This contribution was supported by the Agency for Support of Science and Research (APVV) through financial support number APVV-0100-06 and the Scientific and Educational Grant Agency (VEGA) trough financial support VEGA 1/4116/07

REFERENCES

[1] Gulan L.: Modular Design of Mobile Working Machines. Publishing house SUT in Bratislava, 2000, ISBN 80-227-1397-X

[2] Bukoveczky J., Gulan L., Zajacová Ľ.: Modularity Ratio as Design Criterion. In: Proc. of Géptervezők és Termékfejlesztők XVI. Országos Szemináriuma, Miskolc, 2000. (pp. 49-52)

[3] Gulan, L., Bukoveczky, J.: Platform creation of modular working machines. Gép, 4/2OO6. (pp. 27-29), ISNN 0016-8572

[4] Gulan L., Zajacová Ľ., Izrael G., Filípek P.: Rating of Financial Effectivity of Modular Solutions of Mobile Working Machines. Hungarian Electronic Journal of Science, MET-091205-A, 2009. (6 p.), HU ISSN 1418-7108

Ladislav GULAN, prof. Ing., PhD., Slovak University of Technology, Faculty of Mechanical Engineering, Nám. slobody 17, 812 31 Bratislava, e-mail: ladislav.gulan@stuba.sk

Juraj BUKOVECZKY, prof. Ing., CSc., Széchenyi István University, Faculty of Engineering Sciences, Egyetem tér 1, 9026 Győr, e-mail: buky@sze.hu